EXPOSURE METHOD AND EXPOSURE APPARATUS

FIELD OF THE INVENTION AND RELATED ART

This invention relates to an exposure method,

5   a device manufacturing method and an exposure

apparatus, wherein an exposure process for a substrate

such as a wafer is performed after one or more sample

shot processes are carried out thereto.

The wafer processing procedure for producing

"exposed wafers" mainly comprises sample shot

10   processes such as global tilting for removing any tilt

of a wafer and global alignment for positioning the

wafer, as well as an exposure process. Many attempts

have been made to shortening the time required for

15   each process, to thereby improve the productivity of

"exposed wafers", that is, the throughput.

However, as regards the time for transition

from a certain sample shot process to another sample

shot process or the time for transition from a sample

20   shot process to an exposure process (hereinafter,

"transition time"), no particular attention has been

paid thereto because it is very short as compared with

the time required for each sample shot process itself.

25   ### SUMMARY OF THE INVENTION

It is an object of the present invention to

enable shortening of such transition time to thereby

increase the throughput.

It is another object of the present invention to provide an exposure method, an exposure apparatus and/or a device manufacturing method by which the

5   transition time is shortened.

These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the

10   present invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a flow chart for explaining the

15   sequence flow of a wafer processing procedure, in an embodiment of the present invention.

Figure 2 is a flow chart for explaining the sequence flow for determining the order of processing sample shots in each sample shot process to be done in

20   relation to the wafer processing procedure of Figure 1 and to be made to a wafer having a shot layout such as shown in Figure 3.

Figure 3 is a schematic view of an example of a wafer shot layout, to be processed in relation to

25   the flow chart of Figure 2.

Figure 4 is a flow chart for explaining the sequence flow for determining the positions of and the

order of processing sample shots in each sample shot

process to be done in relation to the wafer processing

procedure of Figure 1 and to be made to a wafer having

a shot layout such as shown in Figure 5.

5   Figure 5 is a schematic view of an example of

a wafer shot layout, to be processed in relation to

the flow chart of Figure 4.

Figure 6 is a flow chart for explaining the

sequence flow for determining the order of processing

10   sample shots in each sample shot process and the order

of processing exposure shots in an exposure process

which are to be done in relation to the wafer

processing procedure of Figure 1 and to be made to a

wafer having a shot layout such as shown in Figure 7.

15   Figure 7 is a schematic view of an example of

a wafer shot layout, to be processed in relation to

the flow chart of Figure 6.

Figures 8A - 8D are schematic views,

respectively, for explaining examples of a first

20   processing shot in an exposure process and the order

of processing the remaining shots in that process, as

determined in accordance with the sequence flow of

Figure 6 example.

Figure 9 is a flow chart of microdevice

25   manufacturing processes.

Figure 10 is a flow chart for explaining

details of a wafer process included in the procedure

of Figure 9.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments of the present

5   invention will now be described with reference to the

accompanying drawings. Briefly, in these embodiments,

the order of processing sample shots, the positions of

sample shots, the processing order in an exposure

process and the like may be determined so as to

10   shorten the distance between the last shot in a

certain sample shot process and the first shot in a

subsequent sample shot process and/or the distance

between the last shot in a certain sample shot process

and the first shot in a subsequent exposure process

15   (hereinafter, "transition distance"). This

effectively shorten the movement time for a stage

which moves through the transition distance.

Figure 1 shows a sequence flow of a wafer

processing procedure in an embodiment of the present

20   invention. As shown in the drawing, as the wafer

processing procedure starts, sample shot processes of

prealignment (step S11), global tilting (step S12) and

global alignment (step S13) are made to a wafer placed

on a wafer stage, in the named order. Then, finally,

25   an exposure process is carried out (step S14).

As regards the prealignment process, the

wafer stage is moved to each sample shot, and the

position of a prealignment mark or marks there is
measured. On the basis of the results of
measurements, the wafer is roughly positioned. In the
global tilting process, the wafer stage is moved to

5   each sample shot, and the focus thereat is measured.
On the basis of the results of measurements, any tilt
of the wafer is removed so that the surface of the
wafer to be exposed is placed horizontally. Then, in
the global alignment process, the wafer stage is moved

10   to each sample shot, and the position of an alignment
mark or marks there is measured. On the basis of the
results of measurements, the wafer is positioned
precisely. After the precise positioning, the wafer
stage is moved to each shot, and exposures of these

15   shots are performed.

There is a transition time from a certain
sample shot process to another sample shot process, or
from a certain sample shot process to an exposure
process. Also, there is a transition distance from

20   the last shot in a certain sample shot process to the
first shot in a subsequent sample shot process or from
the last shot in a certain sample shot process to the
first shot of an exposure process. In some examples
to be described below, the order of processing sample

25   shots, the position of each sample shot, and/or the
order of processing shots in an exposure process is
determined so as to reduce the transition distance

described above, thereby to reduce the movement time
of a stage which moves through the transition
distance. In this manner, the transition time
described above can be shortened.

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[Example of Determining Sample Shot Processing Order]

Figure 2 shows a sequence flow for
determining the order of processing sample shots in
each sample shot process to be made to a wafer having
10 a shot layout such as shown in Figure 3. The number
of sample shots and positions of them in each sample
shot process as well as the shot layout in an exposure
process are selectable. Figure 3 shows an example of
selection. In Figure 3, Pa and Pb denote sample shots
15 for prealignment (two shots in this example), Ta - Td
denote sample shots for global tilting (four shots in
this example), and Aa - Ad are sample shots for global
alignment (four shots in this example). Numbers 1 -
32 denote exposure shot Nos., and the exposure shots
20 No.1 - No.32 are to be exposed in this numerical
order.

As the sequence starts, first, one of the
sample shots Aa - Ad which is closest to the exposure
shot No.1 is determined by calculation on the basis of
25 the X-Y coordinate positions of them (step S21). More
specifically, where the X-Y coordinate of the exposure
shot No.1 is (X_1, Y_1) while the X-Y coordinates of the

sample shots Aa - Ad are (Xa, Ya), (Xb, Yb), (Xc, Yc) and (Xd, Yd), respectively, the distances Da - Dd of the sample shots Aa - Ad from the exposure shot No.1 are given by the following equations.

$$Da = \sqrt{[(Xa-X_1)^2+(Ya-Y_1)^2]}$$

$$Db = \sqrt{[(Xb-X_1)^2+(Yb-Y_1)^2]}$$

$$Dc = \sqrt{[(Xc-X_1)^2+(Yc-Y_1)^2]}$$

$$Dd = \sqrt{[(Xd-X_1)^2+(Yd-Y_1)^2]}$$

Thus, the one shot which corresponds to the smallest one of Da - Dd is detected. In this example, the sample shot Ac is determined so.

Next, the processing order for the sample shots Aa - Ad is so determined that the thus detected shot is taken as the last shot. The first shot to be processed first is named as shot A_1 (step S22). Here, in this example, in the sample shot process, the processing is going to be made to the sample shots counterclockwise. However, any other rule may be used in place of the counterclockwise processing. In this example, therefore, the sample shots will be processed in an order of Ad, Aa, Ab and Ac. The first shot A_1 for the global alignment process is the sample shot Ad.

The above-described procedure for determining

a shot closest to a particular shot, by calculation

on the basis of X-Y coordinate position thereof, can

be applied to any other case to be described below.

Details of the procedure will therefore be omitted in

5   the following description.

Subsequently, in a similar manner, one of the

sample shots Ta - Td for the global tilting process

which is closest to a first processing shot A_1 (Ad) in

the global alignment process, is determined by

10   calculation on the basis of the X-Y coordinate

positions of them (step S23). In this example, the

sample shot Td is detected so. Then, the processing

order for the sample shots Ta - Td is so determined

that the thus detected shot is taken as the last shot.

15   A first shot to be processed first is named as T_1

(step S24). Thus, in this example, the sample shots

will be processed in an order of Ta, Tb, Tc and Td.

The first processing shot T_1 in the global tilting

process is the sample shot Ta.

20   Subsequently, one of the sample shots Pa and

Pb for the prealignment process which is closest to

the first processing shot T_1 (Ta) in the global

tilting process is determined by calculation on the

basis of the X-Y coordinate positions of them (step

25   S25). In this example, the sample shot Pa is

determined so. Then, the processing order for the

sample shots Pa and Pb is so determined that the thus

detected shot is taken as the last shot. The first

shot to be processed first is named P_1 (step S26).

Thus, in this example, the sample shots Pa and Pb will

be processed in an order of Pb and Pa. The first shot

5   P_1 to be processed first in the prealignment process

is the sample shot Pb.

With the procedure described above, all the

sample shot processing orders in every sample shot

process are determined.

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[Example of Determining Sample Shot Position and

Sample Shot Processing Order]

Figure 4 shows a sequence flow for

determining the order of processing sample shots in

each sample shot process to be made to a wafer having

15   a shot layout such as shown in Figure 4. The number

of sample shots in each sample shot process as well as

the shot layout in an exposure process are selectable.

In this example, the selection may be made to be

20   described below. However, in this example, the number

of sample shots for the prealignment process is fixed

to two. More specifically, the number of sample shots

for prealignment is two (fixed), the number of sample

shots for global tilting is four, and the number of

25   sample shots for global alignment is four.

As the sequence flow of Figure 4 starts,

first, shot options to be chosen as sample shots for

global alignment are selected (step S41). In this

example, for better correction precision to wafer

magnification and wafer rotation, a condition that

the options should be those shots located at the

5   outermost periphery of the shot layout is set. Thus,

in this example, the options are those shots marked

with painted circles in Figure 5, that is, the shots

with exposure shot Nos. 1, 2, 3, 4, 5, 10, 11, 16, 17,

22, 23, 28, 29, 30, 31 and 32. However, any other

10   rule may be used for selection of options.

Subsequently, among these shot options, one

which is closest to the exposure shot No.1 is detected

by calculation on the basis of the X-Y coordinate

positions of them (step S42). In this example, the

15   exposure shot No. 1 is determined so. Then, the

positions of sample shots as well as the processing

order of them are so determined that the thus detected

sample shot is taken as the last shot. The first shot

to be processed first is named shot A_1 (step S43). In

20   this example, in the sample shot processes, the sample

shots are processed in a counterclockwise order, and

also these sample shots are placed equidistantly.

However, any other rule may be used in place of the

above. In this example, therefore, first, a shot A_4

25   (exposure shot No.1) is selected as a sample shot and,

then, the remaining sample shots A_2 - A_4 are so

selected that all the sample shots will be processed

in an order of A_1, A_2, A_3 and A_4 and also that these
sample shots are placed equidistantly. Thus, the
first shot A_1 to be processed first in the global
alignment process is exposure shot No.23.

5   Subsequently, in a similar manner, shot
options to be chosen for sample shots in the global
tilting process are selected (step S44). In this
example, for better correction precision to wafer
tilting and for avoiding the influence of a warp of
10   the wafer outer peripheral portion, a condition that
the options should be those shots each being next
(inwardly adjoining) to an outermost peripheral shot
in the shot layout is set. However, any other rule
may be used. In this example, therefore, shot options
15   are those shots marked with non-painted circles in
Figure 5, that is, the shots with exposure shot Nos.
6, 7, 8, 9, 12, 15, 18, 21, 24, 25, 26 and 27. Next,
among these shot options, one which is closest to the
first processing shot A_1 to be processed first in the
20   global alignment process is detected by calculation on
the basis of the X-Y coordinate positions of them
(step S45). In this example, a shot with exposure
shot No.24 is detected so. Subsequently, the
positions of sample shots as well as the processing
25   order for them are determined so that the thus
detected shot is taken as the last shot. The first
shot to be processed first is named shot T_1 (step

S46). In this example, in the sample shot process,
the sample shots are processed in a counterclockwise
order, and also the selection is made so that these
sample shots are placed equidistantly. However, any
other rule may be used in place of the above. In this
example, therefore, first, a shot T_4 (exposure shot
No.24) is selected as a sample shot and, then, the
remaining sample shots T_2 - T_4 are so selected that
all the sample shots will be processed in an order of
T_1, T_2, T_3 and T_4 and also that these sample shots are
placed equidistantly. Thus, the first shot T_1 to be
processed first in the global tilting process is
exposure shot No.27.

Subsequently, shot options to be chosen for
sample shots in the prealignment process are selected
(step S47). In this example, for better correction
precision to wafer rotation, a condition that the
options should be those shots each being located at
the outermost periphery of the shot layout and being
present on a straight line passing through the center
of the shot layout and extending in parallel to the X
axis, is set. However, any other rule may be used.
In this example, therefore, shot options are those
shots marked with triangles in Figure 5, that is, the
shots with exposure shot Nos. 11, 16, 17 and 22.
Next, among these shot options, one which is closest
to the first processing shot T_1 to be processed first

in the global tilting process is detected by

calculation on the basis of the X-Y coordinate

positions of them (step S48). In this example, a shot

with exposure shot No.17 is detected so.

5   Subsequently, the positions of sample shots

as well as the processing order for them are

determined so that the thus detected shot is taken as

the last shot. The first shot to be processed first

is named shot P_1 (step S49). In this example, the

10   number of sample shots for prealignment is fixed to

two, and these two shots should be placed in a

symmetrical relation with each other with respect to

the wafer center. However, any other rule may be

used. In this example, therefore, first, a shot P_2

15   (exposure shot No.17) is selected as a sample shot

and, thereafter, another sample shot P_1 is selected so

that these shots will be processed in an order of P_1

and P_2. Thus, the first processing shot P_1 to be

processed first in the prealignment process is the

20   shot with exposure shot No.11.

With the procedure described above, the

positions of all the sample shots as well as the

sample shot processing orders in every sample shot

process are determined.

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[Example of Determining Processing Order of Sample

Shots and Exposure Shots]

Figure 6 shows a sequence flow for
determining the order of processing sample shots in
each sample shot process as well as the order of
5   processing exposure shots in an exposure process which
are to be made to a wafer having a shot layout such as
shown in Figure 7. The number of sample shots and
positions of them in each sample shot process as well
as the shot layout in the exposure process are
10   selectable. Figure 7 shows an example of selection.
Here, it is assumed that the processing order for
sample shots in the prealignment process is already
determined as an order Pa and Pb, and that the
exposure order is not yet determined. In Figure 7, Pa
15   and Pb denote sample shots for prealignment (two shots
in this example), Ta - Td denote sample shots for
global tilting (four shots in this example), and Aa -
Ad are sample shots for global alignment (four shots
in this example). Also, Ea - Ed denoted shot options
20   for a first processing shot to be processed first in
the exposure process. Numbers 1 - 32 denote exposure
shot Nos. The order of exposure shots is determined
in accordance with the first processing shot. In this
example, the shot options to be chosen for the first
25   processing shot in the exposure process should be
those shots which are located at the opposite ends of
the top or bottom array (row) of the shot layout, that

-15-

is, shots Ea - Ed. Also, when any one of these shots is selected as the first processing shot, the processing order will be determined in a manner as shown in corresponding one of Figures 8A - 8D.

5 However, any other rule may be used.

The processing order in the prealignment process is in the order of Pa and Pb, as described above. Thus, as the sequence starts, first, one of the sample shots Ta - Td which is closest to the Pb is

10 determined by calculation on the basis of the X-Y coordinate positions of them (step S61). In this example, the sample shot Td is determined so. Subsequently, the processing order for the sample shots Ta - Td is so determined that the thus detected

15 shot is taken as the first shot. The last shot to be processed last is named as shot T_4 (step S62). Here, in this example, in the sample shot process, the processing is going to be made to the sample shots counterclockwise. However, any other rule may be used

20 in place of the counterclockwise processing. In this example, therefore, the sample shots will be processed in an order of Td, Ta, Tb and Tc. The first last T_4 for the global tilting process is the sample shot Tc.

Subsequently, in a similar manner, one of the

25 sample shots Aa - Ad which is closest to the shot T_4 (shot Tc) is determined by calculation on the basis of the X-Y coordinate positions of them (step S63). In

this example, the sample shot Ac is detected so.
Then, the processing order for the sample shots Aa -
Ad is so determined that the thus detected shot is
taken as the first processing shot to be processed

5   first. The last shot to be processed last is named as
A_4 (step S64). Thus, in this example, the sample
shots will be processed in an order of Ac, Ad, Aa and
Ab. The last shot A_4 in the global alignment process
is the sample shot Ab.

     Subsequently, among the shots Ea - Eb, one
which is closest to the shot A_4 (shot Ab) is detected
by calculation on the basis of the X-Y coordinate
positions of them (step S65). In this example, the
shot Eb is determined so. Thus, the first processing

15   shot to be processed first in the exposure process is
the shot Eb. Also, the order of exposure process
corresponding to this is determined such as shown in
Figure 8B (step S66).

     With the procedure described above, the order

20   of processing sample shots in each sample shot process
as well as the order of processing exposure shots in
the exposure process are determined.

[Embodiment of Device Manufacturing Method]

25   Next, an embodiment of a semiconductor device
manufacturing method which uses an exposure method
according to any one of the preceding examples, will

be explained.

Figure 9 is a flow chart of procedure for
manufacture of microdevices such as semiconductor
chips (e.g. ICs or LSIs), liquid crystal panels, CCDs,
thin film magnetic heads or micro-machines, for
example.

Step 1 is a design process for designing a
circuit of a semiconductor device. Step 2 is a
process for making a mask on the basis of the circuit
pattern design. Step 3 is a process for preparing a
wafer by using a material such as silicon. Step 4 is
a wafer process (called a pre-process) wherein, by
using the so prepared mask and wafer, circuits are
practically formed on the wafer through lithography.
Step 5 subsequent to this is an assembling step
(called a post-process) wherein the wafer having been
processed by step 4 is formed into semiconductor
chips. This step includes an assembling (dicing and
bonding) process and a packaging (chip sealing)
process. Step 6 is an inspection step wherein
operation check, durability check and so on for the
semiconductor devices provided by step 5, are carried
out. With these processes, semiconductor devices are
completed and they are shipped (step 7).

Figure 10 is a flow chart showing details of
the wafer process.

Step 11 is an oxidation process for oxidizing

the surface of a wafer. Step 12 is a CVD process for

forming an insulating film on the wafer surface. Step

13 is an electrode forming process for forming

electrodes upon the wafer by vapor deposition. Step

5   14 is an ion implanting process for implanting ions to

the wafer. Step 15 is a resist process for applying a

resist (photosensitive material) to the wafer. Step

16 is an exposure process for printing, by exposure,

the circuit pattern of the mask on the wafer through

10   the exposure apparatus described above. Step 17 is a

developing process for developing the exposed wafer.

Step 18 is an etching process for removing portions

other than the developed resist image. Step 19 is a

resist separation process for separating the resist

15   material remaining on the wafer after being subjected

to the etching process. By repeating these processes,

circuit patterns are superposedly formed on the wafer.

     With these processes, high density

microdevices can be manufactured, with a higher

20   productivity.

     In accordance with the embodiments of the

present invention as described hereinbefore, the

transition distance which corresponds to the distance

between the last shot in a certain sample shot process

25   and the first shot in a subsequent sample shot process

or the distance between the last shot in a certain

sample shot process and the first shot in a subsequent

exposure process, can be shortened significantly. Therefore, the movement time of a stage which moves through the transition distance can be shortened significantly. As a result, a processing time per a

5   single substrate to be exposed can be reduced effectively, and also the productivity of "exposed wafers", that is, the throughput, can be improved significantly.

        While the invention has been described with

10   reference to the structures disclosed herein, it is not confined to the details set forth and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.

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